

OVERVIEW OF HABITAT LOSS AND CHANGE

GRASSLAND PLANT COMMUNITIES

The pristine area of western Merced County was part of a grassland and wetland ecosystem sometimes described as California Prairie and Tule Marsh habitats (Fig. 9. Burcham 1957, Munz and Keck 1959). The grassy portion of the region was dominated by perennial grasses that were excellent pasture. Unfortunately, changes in vegetation composition and distribution in the Valley following the arrival of the Spanish in California never were documented (Heady 1988). Nevertheless certain conditions likely occurred and are generally agreed upon by experts. *Stipa pulchra*, a perennial bunchgrass, probably dominated the Valley grassland, particularly at higher elevations that were drier. Interspersed among the bunch grasses were annuals, especially at lower elevations immediately adjacent to wetland habitats in Merced County. The grassland type characteristic of the region occurred on a wide variety of soils with some authors identifying the distribution on as

many as 195 soil series (Barry 1972). Broad-leaved plants, especially perennials with bulbs, were interspersed among the grasses. Herbaceous annuals were dominated by members of the Caryophyllaceae, Compositae, Cruciferae, Labiatea, Leguminosae, and Umbelliferae (Stebbins 1965).

The seeds of alien species were present in the adobe of the earliest Spanish Missions, providing evidence that the first changes in grassland plant composition in California preceded extensive settlement by Europeans (Hendry 1931). However, the timing and extent of these early changes in plant communities is poorly documented. Undoubtedly, some changes in the grassland community probably preceded the period of intensive grazing that began after the mid-1800's. Records indicate that introduced species such as wild oats (*Avena fatua*) and *Brassica nigra* were abundant before livestock overgrazed the area. Certainly, additional changes in the pristine grassland occurred as more

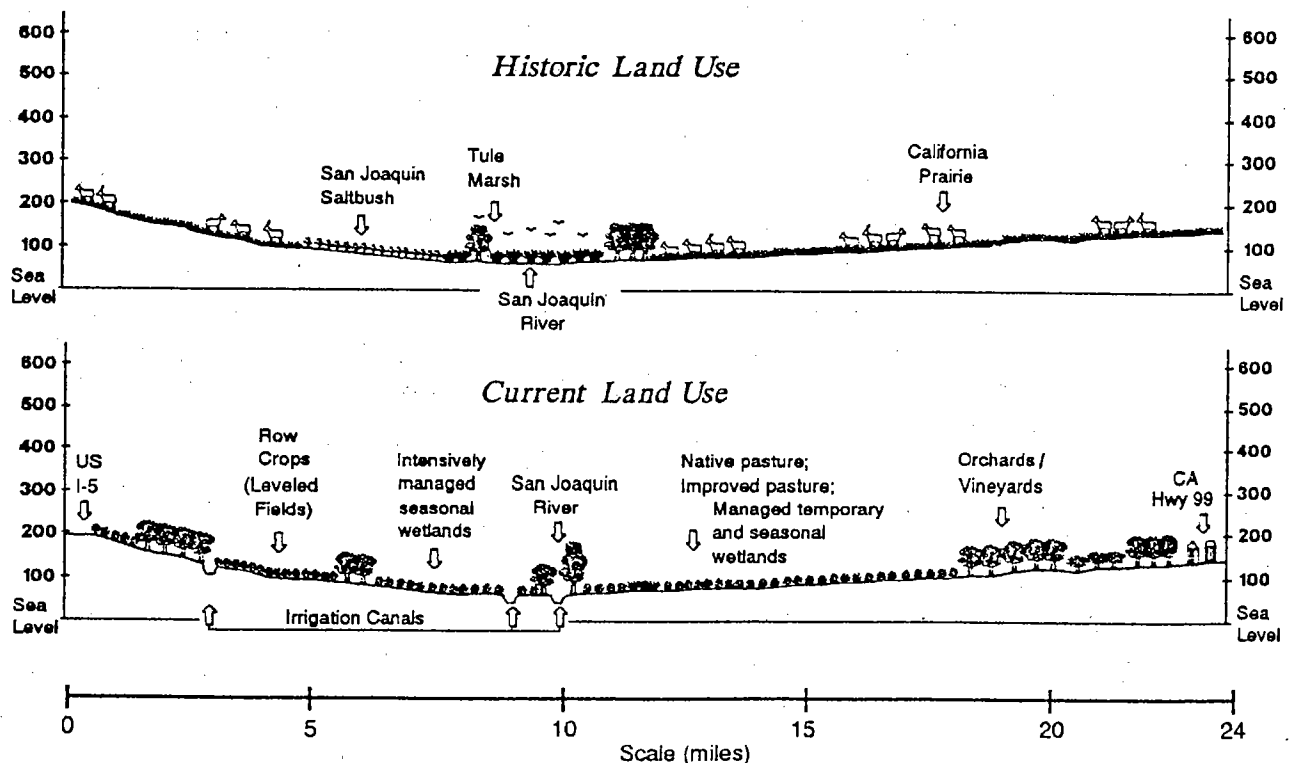


Fig. 9. Comparison of the distribution and type of vegetation communities in the study area before and after agricultural development.

and more settlers arrived in the Valley (Burcham 1957). There is disagreement over the relative importance of how different factors altered the pristine California Prairie (Heady 1988) but at least 4 factors commonly are associated with changes in the prairie community: (1) invasion by alien plant species, (2) changes in the kinds of animals and their grazing patterns, (3) cultivation, and (4) fire, as well as the complicated interactions among these factors (Heady 1988). A major change in the Grasslands was associated with the introduction of domestic livestock. Likewise, the arrival of many alien seeds, bulbs, and cuttings with miners in the 1850's provided another source of plant material that compromised native plant communities. Extensive areas also were converted to dry-land farming with grains and forage as the principal crops (Heady 1988). Those areas that were farmed and have reverted to grassland continue to be dominated by annuals rather than perennials. The role of fire in pristine grasslands is not documented, but fire likely was a part of the evolutionary history of the California Prairie (Heady 1972). Thus, as is the case with any changes in pristine environments, many different factors interacted in combination to result in the demise of the original grassland community in western Merced County.

Historic and current information suggest that the general macroscale distribution of native plant communities has not been influenced by land use changes. Thus, the current distribution of wooded riparian forests, grasslands, marshlands, and shrublands is similar to the distribution during the past several hundred years (Heady 1988). However, the species composition of these communities has changed. The pristine perennial grassland community was dominated by *Stipa pulchra* in association with other perennials including *Aristida hamulosa*, *Elymus glaucus*, *E. triticoides*, *Festuca idahoensis*, *Koeleria cristata*, *Melica californica*, *M. imperfecta*, and *Poa scabrella*. Some annuals were present and included *Aristida oligantha*, *Deschampsia danthonioides*, *Festuca megalura*, *F. pacifica*, and *Orcuttii* spp. The replacement annual grasslands have a composition that is highly variable (McNaughton 1968), but common species include *Bromis mollis*, *B. rigidus*, *B. rubens*, *Erodium botrys*, *E. cicutarium*, and *Avena fatua*.

WETLAND COMMUNITIES

Status of Continental Wetlands

To understand the importance of Grassland habitats, understanding the status of wetlands on a larger scale is necessary. Nationwide, wetlands have received considerable attention since 1985 because of the North American Waterfowl Management Plan and the 1985 Food Security Act. Although exact estimates of the original acreage of wetlands in the 48 coterminous states were never made, experts suggest there were about 220 millions acres of wetlands in colonial America (Dahl 1990). Wetland loss has been excessive during the past 200 years and today less than 100 million acres remain (Dahl and Johnson 1991). Historically, wetland losses primarily have been associated with conversion of native habitats for agricultural purposes. For example, from the mid-1950's to the mid-1970's, 87% of wetland loss was related to agriculture (Frayer et al. 1983). Although this rate has declined to 54% from the mid-1970's to the mid-1980's, agriculture continues to have an important impact on wetland losses. In contrast, urban land uses accounted for about 5% of wetland losses during the 30-year period beginning in the mid-1950's (Tiner 1984).

The total loss of wetlands has been devastating to wildlife populations and has disrupted many wetland values and functions that subsequently compromise economic benefits to society (Odum 1978). Factors such as fragmentation, changes in hydrology, disruption of functions, excessive losses of ephemeral and temporary wetlands, increased sedimentation, and excessive nutrient or toxic chemical loads all have major impacts on remaining wetland habitats or influence the type and duration of use by wildlife (Table 6). Fragmentation of wetland corridors and wetland systems is a national problem and is well-represented by the current discontinuous distribution of remnant wetlands in California.

Status of California Wetlands

California had an estimated 5 million acres of wetlands in the mid-1800's (California Department of Fish and Game 1983). The majority of these wetlands were in the Central Valley, but other sites such as the Klamath

Table 6. Examples of ecological implications resulting from wetland loss and degradation and modified hydrology.

Perturbation	Ecological Implication	
	Habitat	Wildlife
Wetland drainage	Loss of habitat	Populations reduced
Wetland complexes disrupted by highways, farming organization, etc.	Habitat quality decreases	Fewer species present; Resources for some life cycle events eliminated or reduced
Upstream reservoirs	Changed hydrology results in changes of plant species composition and productivity	Some species eliminated; Resources available for lesser number of animals
Nonpoint Pollution	Sediments and pollutants accumulate in wetlands; Undesirable Plant Monocultures become more common	Certain species and/or age classes are impacted; Food production declines

Basin were of great importance to the waterfowl resource (Heitmeyer et al. 1989). Unfortunately more than 95% of these historic wetlands have been destroyed or modified (Frayer et al. 1989, Gilmer et al. 1982). Remnant wetland habitats primarily are within the Central Valley where about 287,000 acres remain. Few if any of these remnant wetlands remain in pristine condition because man has impacted each wetland directly or indirectly. Changes in volume and flow patterns of water, ground water levels and sedimentation rates are just a few examples of the widespread modifications to wetland resulting from man's activity. Privately owned and operated duck clubs are particularly important because they account for two-thirds, or over 170,000 acres, of these wetland habitats. The remaining one-third is divided between state and federal ownership and managed as wildlife areas. Nearly all of these remnant habitats are managed intensively for the benefit of waterbirds, especially waterfowl (Heitmeyer et al. 1989). Significant portions of the Grasslands are now in state or federal ownership or easements (Fig. 3). Efforts to increase public ownership and easements will continue.

Status of San Joaquin Valley Wetlands

The importance of the Grassland study area is imminently clear because of the size, diversity of wetland types, and juxtaposition of remnant habitats (Table 7). Nevertheless, the Grasslands are a tiny remnant of wetlands that historically served as an important wetland corridor between the Delta and the Tulare Basin. Nevertheless, remnant wetlands in the entire San Joaquin Valley account for about half of the remnant wetlands in the Central Valley. Loss of wetlands has been so severe in the Sacramento and San Joaquin valleys that the Grasslands account for about one third of all remaining wetland habitats in the Central Valley even though the original area of the adjacent wetland habitat in the Delta and the Tulare Lake Basin were of greater size and provided habitat for much larger numbers of wildlife. In contrast to the wetland area remaining in the Grasslands, the Delta, which originally encompassed about 450,000 wetland acres, has only about 18,000 acres of wetlands remaining. Unfortunately these habitats occur primarily as sump areas that were created by levee blowouts during floods or as narrow strips of robust emergent vegetation adjacent to rivers and sloughs

Table 7. Status of existing wetlands in the California Central Valley, the Suisun Marsh, and the Delta, 1989.

Basin	Protected ¹			Private	Total	Unprotected ² (%)	Total
	Federal fee title	State fee title	Federal easement				
Sacramento	23,040	8,600	7,935	0	39,575	27,950 (41)	67,525
Delta	0	3,500	0	1,550 ³	5,050	4,300 (45)	9,350
Suisun	1,100	10,900	0	46,000	58,000 ⁴	0 (0)	58,000
San Joaquin	16,580	8,590	28,130	0	53,300	67,000 (55)	120,300
Tulare	2,300	12,105	0	2,325 ⁵	16,730	19,650 (54)	36,380
Totals	43,020	43,695	36,065	49,875	172,655	118,900 (41)	291,555

¹Protected wetlands are those held in fee title by federal, state, or county agency or privately owned wetlands with perpetual conservation easement.

²Any privately owned wetland not covered by a perpetual easement.

³Consumnes Preserve owned by The Nature Conservancy modified from Central Valley Habitat Joint Venture Implementation Plan 1990.

⁴The entire 58,000 acre Suisun Marsh was protected by the Suisun Marsh Protection Act of 1977.

⁵Includes 1,425 acres owned by Kern County.

(Fredrickson et al. 1989, Fredrickson and Laubhan, 1991). This nearly complete destruction and high fragmentation of habitats has reduced wetland values of Delta habitats to minuscule amounts compared to historic values. Similar losses have occurred in the Tulare Lake Basin. Historically, Tulare Lake sometimes reached a total area of over 500,000 acres but today about 36,000 wetland acres are present in the Basin (San Joaquin Valley Drainage Program 1990).

Status of Grassland Wetlands

Wetland habitats within the study area largely fall within three general groups: vernal pools dominated by annual vegetation and temporary flooding regimes, seasonal marshes with annual and perennial vegetation, and tule marshes dominated by robust perennial vegetation with seasonal or semipermanent flooding. The distribution of these three types is distinct with the abundance of vernal pools concentrated at higher elevations and greater distances from the primary floodplain.

Vernal pools—Vernal pools are small basins that occur at higher elevations throughout the study area. The East Grasslands has an abundance of this wetland type. The undulating topography and porous soils of this region, in conjunction with the depth to ground water, determines the number of basins and the total area that is flooded. The hydrology of the vernal

pools is driven by winter rainfall within the study area, whereas the hydrology of the tule marshes is strongly influenced by precipitation events outside the boundaries of the study area.

Many vernal pools were not subject to consistent riverine flooding, thus land use impacts that effect their hydrology are different than for tule marshes. The shallow nature and infrequent flooding of vernal pools make them especially vulnerable to activities such as land leveling, filling by sedimentation, and activities that influence groundwater level. Activities that lower the groundwater table either eliminate vernal flooding or change the length of the flooding regime.

Seasonal Marshes—Seasonal marshes are the most abundant type of wetlands in the study area. They are dominated by alkali bulrush, saltgrass, alkali heath, baltic rush and brassbuttons. Flooding of seasonal marshes is strongly influenced by flows from lateral streams including Los Banos Creek, Creek, Silver Creek, Mud Slough, Garzes Creek, San Luis Creek, and Orestimba Creek. Seasonal wetlands are normally dry by May. Many seasonal basins were not flooded naturally until winter rains began. Where seasonal basins are under intensive management, flooding of some basins may occur as early as September.

Tule Marshes—Tule marsh habitats were distributed within the floodplain of stream sys-

HISTORY OF WATERBIRD POPULATION CHANGES IN THE PACIFIC FLYWAY

PACIFIC FLYWAY

The Pacific Flyway is one of four flyways where cooperating federal, state, and provincial entities provide management direction to benefit waterfowl populations. The political boundary of the Pacific Flyway includes lands west of the continental divide extending from Alaska, southward through the western provinces of Canada and the Rocky mountain states, including western portions of Mexico. Because waterfowl do not follow political boundaries, populations using the Pacific Flyway also breed in areas such as the prairie provinces of Canada or locations in northern Asia that lie outside the area described as the Pacific Flyway. Historically, the Pacific Flyway held the highest concentrations of wintering waterfowl, but this Flyway had the smallest area of native wetland habitats even before man severely disrupted wetland ecosystems (Bellrose 1976). California and Mexico are of critical importance for wintering waterfowl because they provide habitats required by a majority of waterfowl species using this Flyway. Thus, any changes in the area or quality of habitat in California have the potential to influence the outcome of annual cycle events and subsequently the fecundity and mortality of waterfowl populations extending from the prairies of North America to northern Asia (Raveling and Heitmeyer 1989).

IMPORTANCE OF THE CENTRAL VALLEY

Historically, the Central Valley held some of the largest and most impressive concentrations of migratory waterfowl in the Pacific Flyway and North America as well. Early accounts are anecdotal but the descriptions of massive numbers of birds in the Sacramento Valley, the Delta, and the Tulare Basin were consistent even though numbers are vague and the species described might be unclear (Day 1949). As Central Valley wetland habitats were destroyed (Day 1949), there was concern for migratory bird populations extending back to the early 1900's.

California was more fortunate in maintaining large populations of wintering waterfowl into the 1970's than other areas of the United States. Undoubtedly, this was related to the distribution of breeding waterfowl that wintered in California. These populations largely are associated with the more western prairie provinces of Canada and the U.S. that were less affected by land-use changes influencing the area and quality of breeding habitats before 1970. Thus, considerable assemblages of waterfowl continued to congregate in the Central Valley before the 1980's.

Wintering waterfowl populations in the Central Valley have ranged from 8 to 12 million ducks and geese. Although total numbers have declined, the area continues to support 60 percent of the Flyway wintering waterfowl population. Thus, this area is extremely important as the southern terminus or intermediate stopover for Pacific Flyway waterfowl that are produced in the prairies and parklands of western Canada and the river valleys and deltas of Alaska (Kozlik 1975). For example, of 9 basins that consistently winter waterfowl in the Central Valley, the San Joaquin Valley holds 25 percent of the wintering waterfowl population (Heitmeyer 1989) and has 156,680 acres of the 291,555 acres of habitats available in the Central Valley (Table 7).

The significance of the Central Valley wintering habitats is apparent from the peak population objectives for the North American Waterfowl Management Plan (Canadian Wildlife Service and U.S. Fish and Wildlife Service 1986, Central Valley Joint Venture 1990). The goal for ducks in the Central Valley Habitat Joint Venture is a peak population of 4.7 million birds (Table 8). Further, the Central Valley provides habitat for 100% of the Aleutian Canada Geese (*Branta canadensis leucopareia*) and the Tule White-fronted Geese (Table 8), 80% of the Cackling Canada Geese (*B. canadensis minima*) and Ross' Geese, and 66.7% of the Pacific White-fronted Geese (*Anser albifrons*) and Tundra Swan (*Cygnus columbianus*) populations.

Table 8. Peak population objectives for wintering waterfowl established by the Central Valley Habitat Joint Venture relative to those of the North American Waterfowl Management Plan.

	Central Valley	North America	Central Valley as % of total
Total ducks ^a	4,700,000		
Mallard	531,000		
Northern pintail	2,800,000		
Total geese and swans ^b	875,000	5,701,000	15.3
Cackling Canada goose	200,000	250,000	80.0
Aleutian Canada goose	5,000	5,000	100.0
Lesser Snow goose	320,000	1,760,000	18.2
Ross' goose	100,000	125,000	80.2
Tule white-fronted goose	5,000	5,000	100.0
Pacific white-fronted goose	200,000	300,000	66.7
Tundra swan	40,000	60,000	66.7

^aNo winter goals for ducks have been established in the North American Waterfowl Management Plan.

^bReflects recent winter distribution patterns and adjusted for 25% annual recruitment.

GENERAL DECLINE OF WILDLIFE IN FLYWAY

Early reports of wildlife populations in the Valley are poorly documented, but suggest that wild species generally were abundant. Survival and reproduction apparently were high for many species based on the descriptions in these early but poorly documented reports. Clearly, the abundance and distribution of wildlife have changed dramatically since the first settlers reached the Valley over 200 years ago.

Change in size and diversity of wildlife populations is directly related to the changing landscape and the type and intensity of human activities in the study area. The pattern of land use over the past 200 years has moved through a series of stages that influenced plant communities and wildlife populations. Land-use changes were characterized by pulses of activities that impacted large areas or changed the intensity or type of use. The first major modification in native habitats resulted from intensive grazing by domestic stock. This land use changed the plant composition and structural features of the habitat. Nevertheless, areas that were grazed by domestic stock continued to provide open space as well as the required food and habitat for some species. More dramatic changes in the study area occurred where native habitats were converted to agricultural uses other than grazing. Conversion to rowcrops and orchards was far more devastating to the integrity of native habitats than grazing. Despite intensive agricultural practices that require annual cul-

tivation, open space for some wildlife is provided in these agricultural environments. However, overall species richness and the density of many species are reduced greatly. The most severe loss of open space in the study area occurs when agricultural or remnant habitats are replaced by more intense uses where hard surfaces and buildings reduce open space and high levels of human activity create continuous disturbance to natural systems (Murphy 1988).

The biological diversity of the Grasslands likely was little impacted by the first human activity. Asian immigrants largely were hunters and lacked the technology to dramatically influence natural systems with domestic stock or the development of population centers. However, there is some evidence that their hunting activities, and some environmentally related changes, impacted large herbivore populations (Burney 1993). Early settlers had little impact on open space because populations were small and the culture was oriented around hunting. Likewise, the natural hydrology was not impacted because these early cultures lacked the technology to dam rivers or dig channels and did not practice agriculture or graze domestic stock.

Large mammals which require extensive areas of undisturbed habitat to survive and reproduce have been influenced the most by human impacts on natural habitats (Murphy 1988). Grizzly bears (*Ursus arctos*), free-ranging tule elk (*Cervus elaphus nannodes*) and pronghorn antelope (*Antilocarpa americana*) have been extirpated from the San Joaquin Valley for

Table 9. Mean number of selected waterfowl counted in the Central Valley, Suisun Marsh and Delta, winter 1978-87.

Species	Sacramento Valley	San Joaquin Valley (%)	Suisun Marsh	Delta
Mallard	314,712	30,438 (8)	15,221	4,667
Gadwall	11,698	23,137 (65)	602	25
American wigeon	403,038	10,913 (3)	9,318	847
Green-winged teal	16,336	90,479 (79)	6,913	961
Cinnamon teal	137	2,541 (94)	42	2
Northern shoveler	122,557	209,142 (58)	28,456	3,022
Northern pintail	1,429,698	238,191 (13)	60,347	141,190
Canvasback	11,735	2,036 (8)	3,446	7,056
Ring-necked duck	3,896	917 (14)	404	85
Ruddy duck	16,361	15,985 (43)	2,558	2,184
White-fronted geese	20,092	4,884 (9)	6,491	20,768
Snow/Ross geese	304,310	35,397 (10)	82	19,278
Cackling Canada geese	10,792	4,128 (23)	2,520	830
Aleutian Canada geese	360	1,035 (67)	72	59
Tundra swan	21,283	357 (1)	4	19,999

a considerable period. Clearly the reduced size and increasing fragmentation of native habitats in the study area have been foremost in the demise of these native animal populations. Today the smaller habitat remnants are only suitable for providing the necessary space for smaller species. These changes in habitat area and quality have been so extensive that smaller carnivores such as the kit fox are now being severely impacted by land-use changes and have reached a status of endangered.

Today, California remains one of the principal wintering and migratory stopover points for waterfowl using the Pacific Flyway in spite of great habitat loss. Historically, as many as 81 percent of waterfowl band recoveries in California were from waterfowl banded in Alaska (1948). The Central Valley is of foremost importance for migratory and wintering waterfowl, shorebirds and other waterbirds. Although the Central Valley composes only 11 percent of the land area of the state, the area consistently supports 60 percent of the total wintering waterfowl population of the Pacific Flyway.

IMPORTANCE OF GRASSLAND HABITATS FOR BIRDS

Although the most comprehensive information on bird numbers, distribution, and habitat use within the Grasslands relates to waterfowl and shorebirds, many other migratory birds also are

dependent on habitats within the study area. Counts of waterfowl numbers date back to at least the 1940's but information on shorebird numbers, distribution, and chronology of use primarily is from the past 10 years, with the most complete census work between 1988 and 1993. Counts of birds including waterbirds and nonwaterbirds are inconsistent. Numbers and chronology of movements by neotropical migrants is lacking. In contrast, numbers and distribution of raptors are undoubtedly more complete than for groups other than waterfowl and shorebirds.

Waterfowl

Fifteen species of waterfowl commonly use San Joaquin Valley habitats in winter. Concentrations of 5 species of waterfowl account for more than 50% of the wintering waterfowl in California during the period 1978-87 (Table 9). Species using Grassland habitats extensively in winter include gadwall (65%), green-winged teal (79%), cinnamon teal (94%), northern shoveler (58%), and Aleutian Canada Goose (67%). More recently (1985-1989) wintering waterfowl in the San Joaquin Valley have declined (Table 10). For example, Gadwall accounted for 65% of the species in the Central Valley (1978-87) but only 34% in 1985-89. Northern pintail showed a similar decline from 13% to 6.7%.

Table 10. Midwinter (January indices of waterfowl in the San Joaquin Valley, the Central Valley, and the Pacific Flyway, 1985-89 average (percentages). From Bartonek, J. C., USFWS Office Migratory Bird Management 9/13/89.

	San Joaquin Valley	Central Valley	Pacific Flyway
Mallard	23,090 (4.9) ¹	295,559 (76.3) ¹	1,402,119 (21.1) ²
Gadwall	15,722 (34.1)	40,781 (88.5)	55,687 (73.2)
Wigeon	6,480 (1.9)	264,390 (75.8)	489,026 (54.1)
Green-winged teal	50,868 (21.5)	215,076 (90.9)	279,668 (76.9)
Blue-winged teal	1,126 (34.4)	2,332 (71.1)	3,316 (70.3)
Cinnamon teal			
Shoveler	51,557 (20.9)	163,547 (66.2)	256,144 (63.8)
Pintail	55,800 (6.7)	715,377 (86.0)	945,085 (75.7)
SUBTOTAL DABBLERS	200,578 (9.5)	1,697,153 (80.0)	3,431,701 (49.5)
Redhead	176 (24.0)	189 (25.8)	20,285 (0.9)
Canvasback	2,184 (7.3)	3,297 (11.0)	42,411 (7.8)
Scaup	274 (0.3)	285 (0.3)	146,945 (0.2)
Ring-necked duck	1,810 (13.5)	12,273 (91.7)	21,793 (56.3)
Ruddy duck	13,751 (18.2)	25,186 (33.4)	86,991 (29.0)
SUBTOTAL DIVERS	18,674 (6.6)	42,121 (14.9)	503,205 (8.4)
TOTAL DUCKS	221,273 (9.2)	1,743,626 (72.7)	3,996,245 (43.7)
Snow and Ross geese	27,604 (7.5)	308,584 (83.7)	403,756 (76.4)
White-fronted geese	2,814 (3.9)	45,844 (63.9)	71,861 (63.8)
Canada geese	9,822 (15.3)	26,551 (41.4)	323,878 (8.2)
TOTAL GEESE	40,240 (8.0)	380,979 (75.4)	816,624 (46.7)
Tundra Swan	486 (1.0)	34,869 (71.4)	61,121 (57.0)
Coot	18,840 (18.0)	54,359 (51.9)	185,456 (29.3)
TOTAL WATERFOWL	280,839 (9.2)	2,213,833 (72.4)	5,051,006 (43.8)
Cranes	2,282 (31.2)	3,020 (41.3)	17,416 (17.3)

¹ % of 1985-89 Average Index for California

² % Pacific Flyway in Central Valley

Waterfowl that use the Grasslands during the nonbreeding period either use the Grassland habitats (1) as a southern terminus for their annual movements or (2) as a stopover site as they move to or from (e.g., northward staging white-fronted geese) habitats at more southern locations. Species such as the cackling Canada goose, Aleutian Canada goose, lesser snow goose (*Anser caerulescens*) and Ross geese (*Anser rossii*) use the grasslands as a southern terminus during their annual movements (Fig. 10). In contrast species such as the pintail (*Anas acuta*), white-fronted goose, and cinnamon teal (*Anas cyanoptera*) use Grassland habitats as a southern terminus but also as a stopover during movements to wintering habitats in Mexico (Fig. 11). Waterfowl also breed in the Grasslands, the most common nesting

species are mallard (*Anas platyrhynchos*), gadwall (*Anas strepera*), and cinnamon teal.

Shorebirds

During the past decade there has been an increasing interest in waterbirds other than waterfowl. Shorebirds represent a group with high interest to bird watchers. These generally small waterbirds largely exploit shallowly flooded wetland habitats with little vegetation and excellent horizontal visibility. Recent surveys have identified at least 20 species that regularly use Grassland habitats with numbers ranging from a single bird of a rare species to over 100,000 birds of more common species (Kjelmyr et al. 1991, Table 11). Spring migration appears to be one of the most important

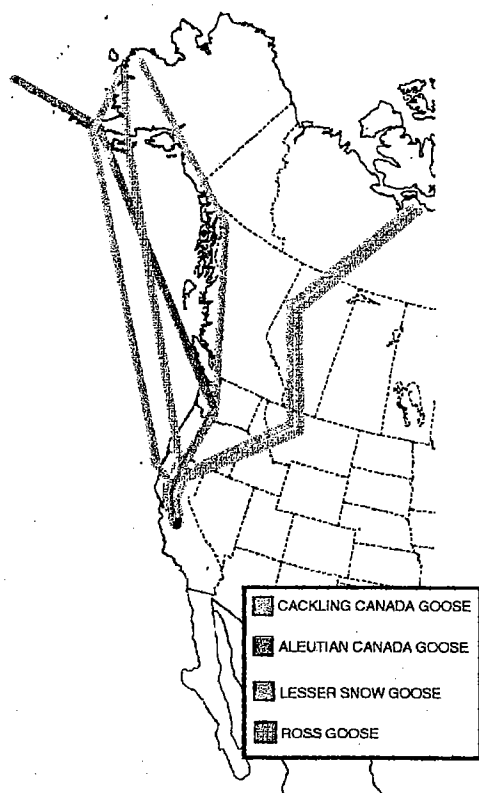


Fig. 10. Migratory movements of geese that use the Grasslands as a southern terminous during winter.

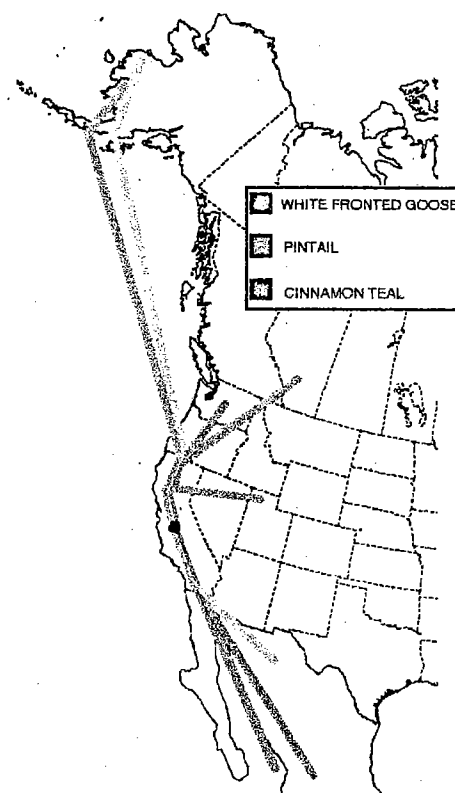


Fig. 11. Migratory pathways of 3 migratory waterfowl that use the Grasslands as a stopover area during migration or as a southern terminous during winter.

Table 11. Summary of shorebird populations surveys (1988-1990 and 1992-1993), Grasslands Wildlife Management Area.

Species	1988-1990			1992-1993
	January	April	September	Winter
Black-bellied plover	582	3,190	653	2,795
Snowy plover	5	21	0	174
Semi-palmated plover	0	286	3	0
Killdeer	366	211	334	2,517
Black-necked stilt	4,038	3,024	2,634	6,179
American avocet	994	3,068	352	2,050
Greater yellowlegs	351	223	323	1,270 ¹
Lesser yellowlegs	9	57	139	1
Solitary sandpiper	0	1	0	0
Willet	0	6	0	40
Spotted sandpiper	0		1	0
Whimbrel	0	187	0	0
Long-billed curlew	115	31	1,687	1,012
Sanderling	125	0	0	0
Marbled godwit	0	87	4	121
Western/least sandpiper	11,051	118,778	2,277	19,425
Dunlin	20,007	48,437	25	26,824
Dowitcher spp.	24,733	38,971	3,357	29,922
Common snipe	90	41	10	175
Red-necked phalarope	0	2	13	0
Ruff	0	1	0	0
TOTAL	62,466	216,624	11,812	92,517

Table 13. Estimates of bird use other than waterfowl reported in the Grasslands (West Grasslands 1978)

Group/Species	Type of use	Average production	Estimated number		Average duration of use (weeks)
			Average	Peak	
OTHER MIGRATORY BIRDS					
Brewers blackbird	b,w,f,s	4,000			52
Yellow-headed blackbird	b,w,f,s	600			52
Redwing blackbird	b,w,f,s	6,000	1,000,000	5,000,000	52
Tricolored blackbird	b,w,f,s	1,000			52
Starling	b,w,f,s	10,000	500,000	2,000,000	52
Burrowing owl	b,w,f,s	150	500	800	52
Great-horned owl	b,w,f,s		75	150	52
Short-eared owl	w,f			20	26
Marsh hawk	b,w,f,s		300	600	52
Red-tailed hawk	b,w,f,s	100	300	600	52
American kestrel	b,w,f,s	400	1,000	2,500	52
Red-shouldered hawk	b,w,f,s	20		10	52
Rough-legged hawk	w,f		2	12	26
Ferruginous hawk	w,f			1	26
Swainson's hawk	b,w,f,s	60	10	50	52
White-tailed kite	b,w,f,s	70	75	300	52
Prairie falcon	w,f		2	6	26
Sharp-shinned hawk	w,f		20	40	26
Golden eagle	w,f,s		6	15	39
Turkey vulture	w,f,s		35	100	39
Mourning dove	b,w,f,s	3,500		10,000	52
Total			25,900	1,507,325	7,025,204
RESIDENT WILDLIFE					
California quail	b,w,f,s	250	200	400	
Ring-necked pheasant	b,w,f,s	300	250	500	
Total		550	450	900	

b = breeding, nesting, brood; w = wintering; f = feeding; s = summer. Degree of accuracy of these estimates is unknown and some important species are missing including bald eagle, peregrine falcon, barn owl, marsh wren, and Cooper's hawk.

waterfowl. At least 15 waterbird species other than shorebirds and waterfowl use Grassland habitats, 8 of which breed in the area (Table 12). The most abundant are great blue heron, black-crowned night-heron (*Nycticorax nycticorax*), common moorhen (*Gallinula chloropus*) and sora (*Porzana carolina*).

Other birds

Although populations estimates are lacking for most other birds, some information is available for certain groups because of their potential to cause agricultural depredations or because

they are threatened or endangered (Table 13). Raptor abundance and distribution probably are most complete because a large body size allows easier identification and census and there is concern for their status. In contrast, smaller birds often have secretive habits and are difficult to census. The most abundant group is blackbirds which total over 1 million birds on average with peaks exceeding 7 million.

Threatened and Endangered species

Intensive land use has resulted in widespread changes in numbers and distribu-

tion, as well as extirpation and/or extinction, of plants and animals native to California. Some species have disappeared from the state. In 1990 72 animals and 140 plants were classed as threatened or endangered. There is concern that 60 additional animals and 600 additional plants may face serious reduction or extinction (Department of Fish and Game 1991). Thus, remaining habitats, especially those of larger size, are of critical importance in maintaining the viability of species with decreasing populations.

The Grasslands study area includes habitats that are identified as having potential value to threatened and endangered species (U.S. Fish and Wildlife Service 1990, W. White pers. comm). Eleven species are listed as endangered by federal assessment and include two reptiles, the blunt-nosed leopard lizard (*Gambelia silus*) and giant garter snake (*Thamnophis gigas*); two birds, the American peregrine falcon (*Falco peregrinus anatum*) and least bell's vireo (*Vireo bellii pusillus*); and three mammals, the San Joaquin kit fox (*Vulpes macrotis mitica*), Fresno kangaroo rat (*Dipodomys nitratoideis exilis*) and giant kangaroo rat (*D. ingens*); 3 invertebrates, Conservancy fairy shrimp (*Branchinecta conservatio*), longhorn fairy shrimp (*Branchinecta longiantenna*), and vernal pool tadpole shrimp (*Lepidurus packardii*); and one plant, Palmate-bracted bird's beak (*Cordylanthus palmatus*). Threatened species according to federal standards in the study area include two birds, the Aleutian Canada goose (*Branta canadensis leucopareia*) and bald eagle (*Haliaeetus leucocephalus*); two invertebrates, valley elderberry longhorn beetle (*Desmocerus californicus dimorphus*) and vernal pool fairy shrimp (*Branchinecta lynchi*); and one plant, Palmate-bracted bird's beak, (*Cordylanthus palmatus*). The U.S. Fish and Wildlife Service and the state of California also have generated lists of proposed and candidate species that includes am-

phibians, reptiles, birds, mammals, invertebrates, and plants (Table 14).

The fauna and flora of the Grasslands have specific requirements that control reproductive success and survival. Collectively, the degree of individual success determines population size and fluctuations, as well as extirpations and extinctions. Over geologic time, extinctions and extirpations are common. However, human populations and their activities have created conditions that have accelerated changes in native animal and plant populations and distribution patterns. In fact, some scientists have stated that the rate of extinction is higher today than during the period when dinosaur extinctions occurred. Foremost among these perturbations are those that modify or destroy plant communities and the amount and distribution of open space. Thus, agriculture and urbanization are two of the most common threats associated with human activities that impact ecosystems and subsequently the size and distribution of wildlife populations (Murphy 1988, Warner and Brady 1994).

An understanding of these effects requires information on habitat requirements and chronology of use relative to life history events of individual species. In this report we focus on waterfowl life history requirements because of the high interest in this species group by individuals and agencies associated with the Grasslands. General requirements for a few select species other than waterfowl also are included. However, it must be remembered that successful completion of life history events for any species is dependent on ecosystem conditions. Thus, it is not possible to separate habitat perturbations from populations dynamics, nor is it possible to look solely at waterfowl species without considering other animal and plant assemblages.

Table 14. Proposed, threatened and endangered species in the Grasslands study area of concern to state and federal agencies.

Taxonomic Group	Species	Status	
		Federal	State
Amphibians			
	California tiger salamander, <i>Ambystoma californiense</i>	2	CSC
	California red-legged frog, <i>Rana aurora draytonii</i>	1	CSC
	Western spadefoot, <i>Scaphiopus hammondi</i>		CSC
Reptiles			
	Blunt-nosed leopard lizard, <i>Gambelia silus</i>	E	E
	Giant garter snake, <i>Thamnophis gigas</i>	E	T
	Western pond turtle, <i>Clemmys marmorata</i>	2	CSC
	California horned lizard, <i>Phrynosoma coronatum frontale</i>		CSC
	Silvery legless lizard, <i>Anniella pulchra pulchra</i>		CSC
	San Joaquin whipsnake, <i>Masticophis flagellum ruddocki</i>		CSC
Birds			
	Bald eagle, <i>Haliaeetus leucocephalus</i>	T	E
	Peregrine falcon, <i>Falco peregrinus anatum</i>	E	E
	Aleutian Canada goose, <i>Branta canadensis leucopareia</i>	T	
	Least bell's vireo, <i>Vireo bellii pusillus</i>	E	E
	Ferruginous hawk, <i>Buteo regalis</i>	2	CSC
	White-faced ibis, <i>Plegadis chihi</i>	2	CSC
	Western snowy plover, <i>Charadrius alexandrinus nivosus</i>	PT	CSC
	Mountain plover, <i>Charadrius montanus</i>	2	CSC
	Black tern, <i>Chlidonias niger</i>	2	CSC
	Long-billed curlew, <i>Numenius americanus</i>	3C	CSC
	Fulvous whistling duck, <i>Dendrocygna bicolor</i>	2	CSC
	Tricolored blackbird, <i>Agelaius tricolor</i>	2	CSC
	California horned lark, <i>Eremophila alpestris actia</i>	2	CSC
	Loggerhead shrike, <i>Lanis ludovicianus</i>	2	CSC
	Western least bittern, <i>Ixobrychus exilis hesperis</i>	2	CSC
	Swainson's hawk, <i>Buteo swainsoni</i>		T
	Cooper's hawk, <i>Accipiter cooperii</i>		CSC
	Sharp-shinned hawk, <i>Accipiter striatus</i>		CSC
	Golden eagle, <i>Aquila chrysaetos</i>		CSC
	Northern harrier, <i>Circus cyaneus</i>		CSC
	Osprey, <i>Pandion haliaetus</i>		CSC
	Prairie falcon, <i>Falco mexicanus</i>		CSC
	Merlin, <i>Falco columbarius</i>		CSC
	Short-eared owl, <i>Asio flammeus</i>		CSC
	Long-eared owl, <i>Asio otus</i>		CSC
	Western burrowing owl, <i>Athene cunicularia</i>		CSC
	Greater sandhill crane, <i>Grus canadensis tabida</i>		T
	White pelican, <i>Pelecanus erythrorhynchos</i>		CSC
	Double-crested cormorant, <i>Phalacrocorax auritus</i>		CSC
	Western yellow-billed cuckoo, <i>Coccyzus americanus</i>		E
	Willow flycatcher, <i>Empidonax flsiventris (traillii)</i>		E
	Yellow warbler, <i>Dendroica petechia brewsteri</i>		CSC

Table 14. (cont.) Proposed, threatened and endangered species in the Grasslands study area of concern to state and federal agencies.

Taxonomic Group	Species	Status	
		Federal	State
Mammals			
	San Joaquin Kit Fox, <i>Vulpes macrotis mutica</i>	E	T
	Giant kangaroo rat, <i>Dipodomys ingens</i>	E	E
	Fresno kangaroo rat, <i>Dipodomys nitratoides exilis</i>	E	E
	Southwestern otter, <i>Lutra canadensis sonora</i>	2	CSC
	San Joaquin antelope squirrel <i>Ammospermophilus nelsoni</i>	1	T
	San Joaquin Valley woodrat, <i>Neotoma fuscipes riparia</i>	1	CSC
	San Joaquin pocket mouse, <i>Perognathus inornatus inornatus</i>	3B	
	Spotted bat, <i>Euderma maculatum</i>	2	CSC
	California mastiff bat, <i>Eumops perotis californicus</i>	2	CSC
	Arizona myotis, <i>Myotis lucifugus occultus</i>	2	CSC
	Townsend's western big-eared bat, <i>Plecotus townsendii townsendii</i>	2	CSC
	Badger, <i>Taxidea taxus</i>		CSC
Invertebrates			
	Valley elderberry longhorn beetle, <i>Desmocerus californicus dimorphus</i>	T	
	Conservancy fairy shrimp, <i>Branchinecta conservatio</i>	E	
	Longhorn fairy shrimp, <i>Branchinecta longiantenna</i>	E	
	Vernal pool fairy shrimp, <i>Branchinecta lynchi</i>	T	
	California linderiella, <i>Linderiella occidentalis</i>	PE	
	Vernal pool tadpole shrimp, <i>Lepidurus packardii</i>	E	
Plants			
	Palmate-bracted bird's beak, <i>Cordylanthus palmatus</i>	E	E
	San Joaquin Valley Orcutt grass, <i>Orcuttia inaequalis</i>	PE	E
	Hispid bird's-beak, <i>Cordylanthus mollis</i> ssp. <i>hispidus</i>	2	
	Delta button celery, <i>Eryngium racemosum</i>	2	E
	Colusa grass, <i>Neostapsia colusana</i>	PT	E
	Merced phacelia, <i>Phacelia ciliata</i> var. <i>opaca</i>	2	
	Bearded allocarya, <i>Plagiobothrys hystriculus</i>	3A	
	Heartscale, <i>Atriplex cordulata</i>	2	
	Valley spearscale, <i>Atriplex joaquiniana</i>	2	
	Slough thistle, <i>Cirsium crassicaule</i>	2	

E = Endangered

T = Threatened

PE = Proposed for listing as endangered

PT = Proposed for listing as threatened

1 = Candidate 1, FWS has information on taxa to support a listing proposal

2 = Candidate 2, listing may be appropriate, but FWS needs additional information to support any listing

3A = Species considered extinct

3B = Taxa no longer regarded as separate subspecies

3C = Taxa found to be more abundant than previously believed.

FUNCTIONAL ASPECTS OF THE GRASSLAND ECOSYSTEM

To understand the impacts of land use on wetland communities, a conceptual framework of wetland values and functions is essential. This section describes the intricacies of wetland habitats and the complexities animals face in meeting life history requirements.

WETLANDS: A CONCEPTUAL PERSPECTIVE.

Wetlands are best described as transitional habitats between aquatic and terrestrial systems where the water table usually is at or near the surface or the land is covered by shallow water (Mitsch and Gosselink 1993:25). Wetlands are characterized by having one or more of the following attributes: (1) at least periodically, the land supports predominantly hydrophytes (plants adapted to flooded conditions), (2) the substrate is predominantly undrained hydric

soil, and (3) the substrate is nonsoil and is saturated with water or covered by shallow water at some time during the growing season of each year. Wetlands classed as palustrine are the most common type in the Grasslands (Cowardin et al. 1979). Dynamic changes among seasons and years are characteristic of all wetlands where organic material, nutrients and energy flow into and from the system. Within the study area, the California Prairie surrounds the floodplain and is interspersed among depressions that are characterized as vernal pools, sloughs, and other wetland habitats. Uplands surrounding wetlands are integrally linked to the wetland basin or system. A conceptual model of wetlands (Fig. 13) depicts important biotic and abiotic components related to habitat values and functions of importance to wildlife. These components are surrounded by a dotted line

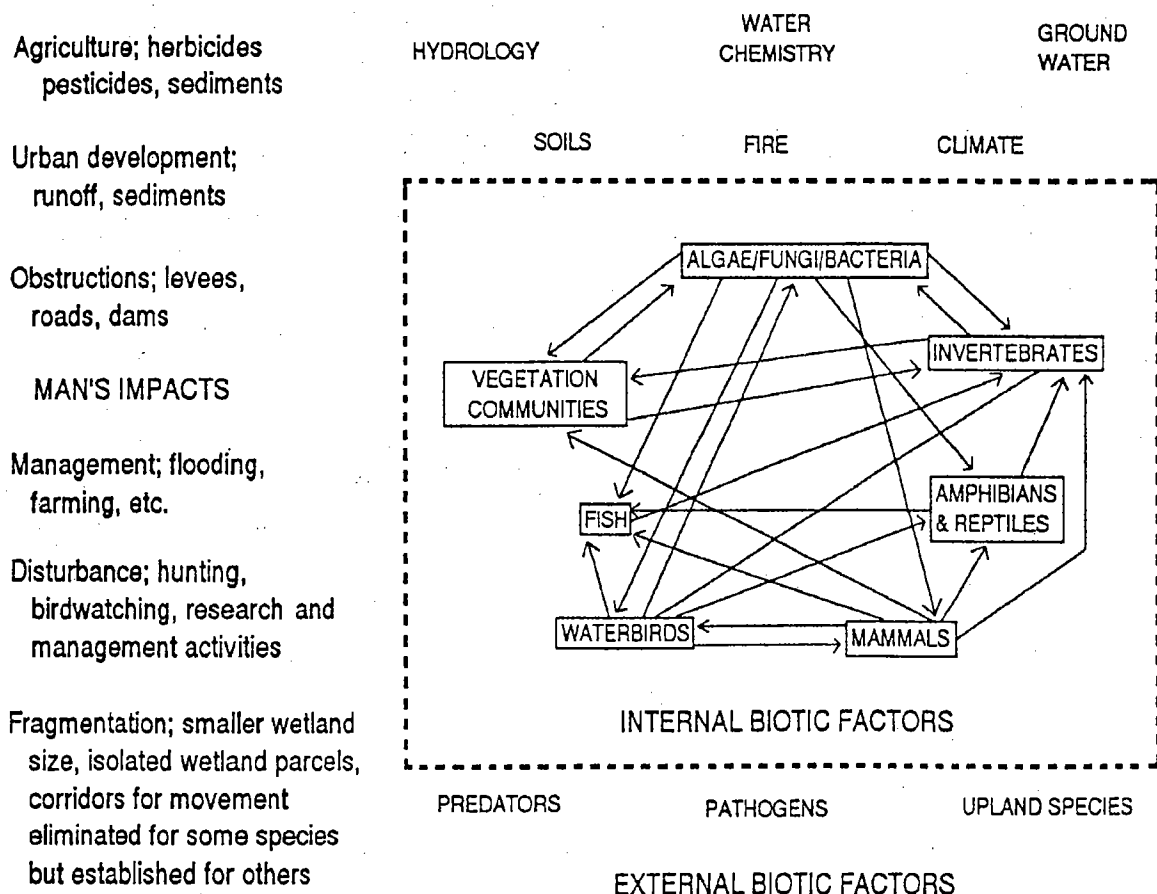


Fig. 13. A conceptual wetland model. The dotted line indicates the indistinct boundary of a wetland and suggests that energy and nutrients flow into and from the wetland.

to indicate the transitional nature of wetlands and to suggest nutrient transport into and from the system. In this model the wetlands in Merced County are used as an example of the important wetland ecosystem components between the Coast Range and the Sierra Nevada before development. Factors that influence these components fall into two distinct groups; Abiotic (non-living) and Biotic (living).

Abiotic Factors

Abiotic factors (e.g., physical and chemical) include hydrology, ground water, soils, climate, fire, and water chemistry. Foremost among these factors is hydrology because the time, duration, and depth of flooding not only control productivity of plant communities but also determine the value of habitats for myriad wildlife. Historically the hydrology in Merced County was influenced by flooding events that fall into two general categories: within Valley rainfall that occurs primarily in winter, and melt water from Sierra Nevada snowpack that primarily occurs in spring (Ogden 1988, San Joaquin Valley Drainage Program, 1990). The combination of these events created dynamic flooding conditions within Grassland wetlands. Wetlands at low elevations within the floodplain of the San Joaquin River had a high flood frequency whereas wetlands at higher elevations flooded less frequently.

The complex interactions among hydrology and climatic factors determine soil and water chemistry (e.g., salinity), which in turn influence plant community establishment and productivity, decomposition and nutrient cycling in Grassland wetlands. These factors directly influence the amount and type of food and cover available during the annual cycle of waterfowl and other wildlife.

Other factors strongly influencing wetland dynamics are related to man's activities and include: agriculture practices; developments for irrigation and urban water; construction of roads, levees, and canals; wetland and wildlife management practices such as flooding, drawdowns, and farming; and urbanization and industrial developments (Fredrickson and Reid 1990). Agricultural practices have many impacts resulting in sedimentation, soil subsidence, accumulations of herbicides, pesticides, and fertilizers, pollution of agricultural drainwater with soils concentrations of elements such as selenium and boron. In

California, human impacts that compromise wetland values and functions are as diverse, extensive, and intensive, if not more so, than those that occur in other states.

Biotic Factors

Biological factors, such as disease, predation, and competition, exert important influences on wetland community dynamics and productivity, which directly or indirectly influence waterfowl and other wildlife.

Components of wetland communities closely associated with wildlife use are: plants (algae, perennials, annuals), wetland macroinvertebrates, and decomposing vegetation. The dynamic interactions among biotic and abiotic components provide a basis for understanding land-use impacts on California's wetlands, thereby identifying opportunities to protect, restore and manage these important habitats. These different components have varying roles in providing food and cover for wetland wildlife. Each plant has its specific role or value in a wetland that is highly variable depending on the time of year and stage in the life cycle of the plant or animal. Some plants only provide food, others provide both food and cover and some play a major role only as cover. Additionally, plants are of critical importance in the nutrient dynamics within wetlands.

ALGAE AND DUCKWEED

Although poorly studied, algae and duckweeds respond quickly to readily available nutrients in the water column and can account for a large proportion of annual productivity. There is good evidence that algae plays an important role in tying up readily available nutrients thereby preventing export from wetland basins. Furthermore, algae are an important component in the decomposition process. Immediately after plant litter accumulates, algae colonize living and dead material and play a key role in conditioning the litter for macroinvertebrates. Algae serve as a source of food for many invertebrates and for some vertebrates as well (Euliss and Grodhaus 1987). For example, species such as American coot (*Fulica americana*) and gadwall readily consume algae.

ANNUAL MARSH VEGETATION

Annual vegetation characteristically is associated with portions of wetland basins that exhibit seasonal water fluctuations. Ephemeral,

temporary, and seasonal wetlands, as well as higher elevations in semipermanent wetlands that are exposed during the hottest and driest portions of the year, typically have a predominance of annual vegetation.

Some of these annual plant species always are associated with wetlands, whereas during drier seasons or at the highest elevations within a basin annual vegetation classed as terrestrial is most likely to develop.

Common annual wetland plants in the Grasslands include watergrass (*Echinochloa* spp.), smartweeds (*Polygonum* spp.), swamp timothy (*Heleochoa schoenoides*), and sprangletop (*Lepetochloa* spp.). Annual plants are particularly important as seed producers and species that have a complex plant structure such as smartweed also provide important substrates for aquatic invertebrates once they are flooded (Severson 1987).

PERENNIAL MARSH VEGETATION

Cattails (*Typha* spp.), hardstem bulrush (*Scirpus acuta*) and alkali bulrush (*S. robustus*) are typical examples of perennial marsh vegetation with a ubiquitous distribution in Grassland wetlands. Such robust plants serve a particularly valuable role in providing breeding habitat and cover for waterfowl as well as other waterbirds. The robust structure of these plants provides materials for nest construction, sites for nest attachment, cover from predators, and largely determine the cover/water interspersation that provides seclusion for pairs. This robust vegetation also provides important cover for broods. During other times of the year when weather conditions are harsh, tule marshes provide protective cover that appear to give birds a "thermal advantage". However, too much robust vegetation is undesirable. When dense monocultures of robust vegetation develop throughout a marsh system, the wetland loses value and use of the basin by waterbirds declines.

Some perennial marsh plants, such as hardstem and alkali bulrush, produce foods of value to wildlife. In contrast, some species produce abundant seed that is of little or no value as a food source for vertebrates because the seeds are too small or have a hard seed coat. Hard seeds are difficult to digest and often pass through the digestive tract intact (Buckley 1989). However, the underground parts and some fleshy plant material of these species may

be used by some avian grazers (e.g., geese), muskrats and beaver.

Perennial marsh plants produce a tremendous amount of biomass annually. In prairie marsh systems cattails may produce 12 tons/acre/year. In most areas of California, these marsh plants senesce because of seasonal environmental conditions related to droughts or climate. Following senescence, this robust litter serves as an important nutrient source for certain invertebrate communities (e.g., substrate, food).

INVERTEBRATES

California's wetlands provide many habitat niches for invertebrates, which are important foods for many wetland wildlife. Furthermore, invertebrates play an important role in decomposition and nutrient cycling processes (Merritt et al. 1984, Reid 1985, Magee 1993, Fig. 14). Invertebrates have myriad life history strategies that allow them to exploit such diverse habitats as bottom substrates; submergent, floating and emergent vegetation; leaf litter from herbaceous and woody vegetation; accumulated organic matter; and the water surface (Minshall 1984, Fredrickson and Reid 1988a). Each habitat type has a distinctive invertebrate community that is adapted to the characteristic hydrology, vegetation structure, and water quality of the wetland basin. Because invertebrates are so abundant and serve as an important source of protein, they provide a critical nutrient link between detrital resources, plant community structure and wildlife (Batema et al. 1985). In the Grasslands, swamp timothy and watergrass provide habitats for invertebrate groups of importance to wildlife (Severson 1987).

Adaptation and response to natural hydrological regimes

Short and long-term hydrologic regimes have shaped the life history strategies of wetland macroinvertebrates. These strategies are based on adaptations of macroinvertebrates to tolerate or avoid drought. Adaptations that have evolved as a result of long-term hydrologic cycles require one or more of the following characteristics: (1) the ability to withstand drought in the egg, pupal or larval state; (2) rapid growth; (3) the ability to produce numerous offspring; (4) the ability to complete the life cycle within one year and (5) high mobility.

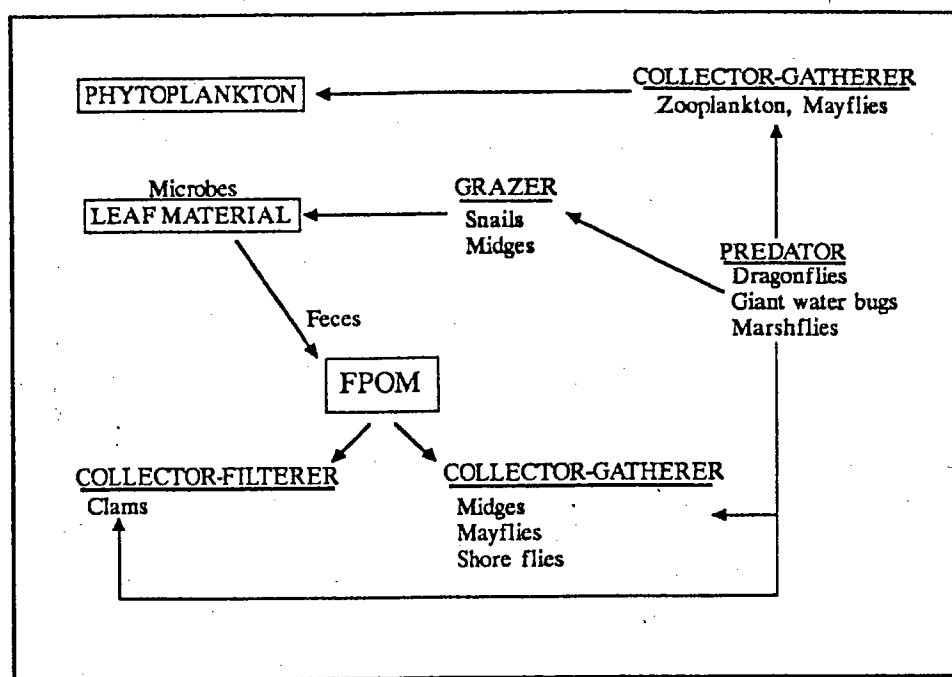


Fig. 14. Invertebrate functional groups associated with herbaceous seasonal and perennial marshes in the Grasslands.

The ability to withstand drought is an important characteristic shared by many macroinvertebrates that are common in Grassland wetlands (Reid 1985, Fredrickson and Reid 1988). Understanding life history strategies is important to predict how perturbations might impact invertebrate populations and their functional role in wetland systems. Several invertebrate groups including flatworms; fairy, clam and seed shrimp; water fleas; mayflies, mosquitoes; phantom midges; and marsh flies all represent species with drought resistant egg stages. In contrast, oligochaete worms may use mucosal secretions to survive drought, whereas chironomid larvae often resist drought by aestivating in cocoons. Fingernail clams rely on their shell to resist dessication, but also burrow into the wet litter layer to avoid predation, disease and drought. Isopods and amphipods have no morphological adaptations to resist drought, but will aestivate as adults and appear to find adequate moisture during the dry season within the deeper litter layers or in refugia that remain flooded.

Because of the dynamic nature of the flooding regimes in Grassland wetlands, macroinvertebrates that grow rapidly while water and

nutrients are available have an advantage. Furthermore, producing large numbers of offspring and completing the life cycle within a year allow for greater success for each species. When water levels decline, species that cannot tolerate drought must be able to avoid dry conditions. Thus, species that avoid drought successfully often are highly mobile; either moving to deeper water or emigrating from the basin. Beetles and hemipterans, in particular, respond well to drawdowns by having an aerial dispersal to more permanent waters (Fredrickson and Reid 1988).

Although long-term hydrologic cycles influence adaptive strategies of invertebrates, their occurrence, growth and reproduction at any given time is determined by short-term water regimes and abiotic and biotic factors. The presence of wetland macroinvertebrates in newly flooded wetlands is apparent soon after inundation by floodwaters. Peaks in abundance are often dramatic and short-lived as invertebrates respond to fluctuating water levels and nutrient inputs. This general response of "pulsing" by invertebrate populations, although variable among years and habitat types, is typical of invertebrates that exploit fluctuating waters and nutrient rich detrital resources. Nutrients

and organic matter are rapidly leached from leaf litter and detritus upon initial contact with flood waters. This leaching results in rapid increases in nutrient concentrations in standing water. Waterfowl that exploit macroinvertebrates as food resources are influenced by these dramatic invertebrate pulses. Thus waterfowl numbers and distribution during certain portions of the annual cycle partially reflect the abundance, availability and distribution of macroinvertebrates.

VERTEBRATES

Vertebrates are the most obvious and best understood members of wetland communities. They tend to have large body sizes compared to invertebrates and represent consumer groups at the upper end of the food chain (Fig. 15). Water-

birds represent the most visible vertebrate component because, in addition to a large body size, many species exhibit bright colors, high mobility, interesting behavior including songs and calls, and diurnal activity. In addition many birds often form large concentrations during winter or migration that regularly attract public attention. The most adaptable waterbird group is waterfowl because they fill many niches in wetlands; some primarily are herbivores, some are omnivores, while others are carnivores.

Frogs, toads, and snakes tend to be smaller than many waterbirds and are less mobile. Apparently amphibians are less adaptable to changing conditions or modification in wetland environments because their numbers have dropped precipitously at many locations across the continent. This group usually is less visible

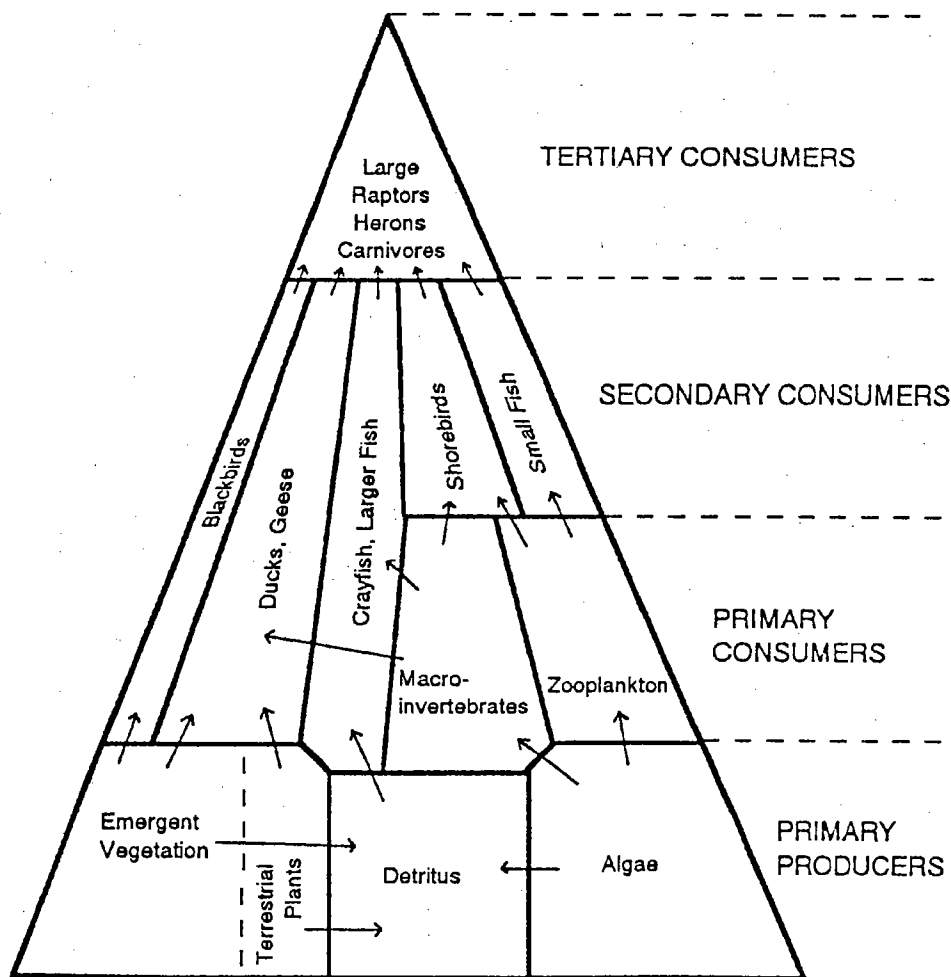


Fig. 15. Trophic pyramid of Grassland wetlands.

than birds because they tend to be nocturnal, only vocalize during the breeding season, and remain buried in mud, under water or in dense cover for most of their life cycle. Some reptiles (snakes and turtles) have been severely impacted by wetland loss and modification. The giant garter snake is an example of a federally listed threatened species present in the Grasslands. Fish are the other cold blooded vertebrates found in wetlands; but their abundance is limited in the seasonal wetlands, of the San Joaquin Valley.

Although mammals require water as a basic life requisite, few have completely adapted to aquatic environments (Weller 1987). The most abundant forms are herbivores such as muskrats and beaver. By comparison, carnivores are not abundant, but their predatory habits may have an important influence on other animal populations by influencing breeding success or mortality rates of young animals.

Vertebrates serve as the "canaries" in wetland systems. Their numbers, distribution, and reproductive success are indicators of wetland conditions. For example, listing of the giant garter snake suggests that some important habitats required for life history success have been compromised in the Grasslands. The distribution, size and fecundity of the less mobile vertebrate populations are the most sensitive indicators to changing wetland conditions, but many of these species are so poorly understood that detecting changes in populations or distribution is difficult. Birds serve as more obvious indicators of changing conditions because their numbers and distribution are much easier to document.

Birds are important consumers in the Grasslands study area. The abundance of herons and raptors is low compared to other bird groups because they are at the top of the trophic pyramid (Fig. 15). Ducks and geese are classed as primary and secondary consumers; whereas shorebirds are secondary consumers because they are predominantly carnivores. Because waterfowl have been so well studied, they will serve as a model to describe their role in the wetland system.

Waterfowl Life History Strategies

Waterfowl are well adapted to exploit the dynamic wetland and upland habitats associated with the Grasslands. Compared to

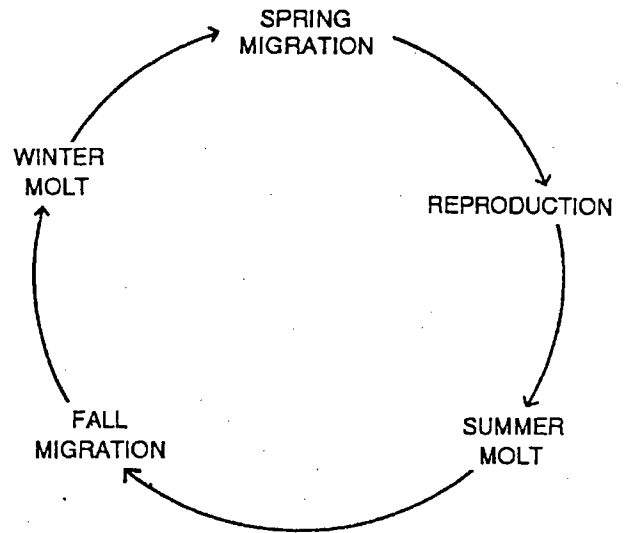


Fig. 16. The five major life cycle events of a typical dabbling duck such as a pintail.

other birds, waterfowl have large body sizes. Geese and swans are largest, and ducks are smallest (Bellrose 1976). Ducks vary considerably in size from the largest, such as mallards, to the smallest in North America, the teal. The large body size enables waterfowl to store a considerable amount of energy and/or protein that can be readily used for future needs. Thus, body size alone has an important influence on flight distances, fasting time, and thermal regulation. Furthermore, waterfowl are highly mobile and can move long distances in short time periods. This high mobility allows waterfowl to effectively exploit wetland habitats across the continent. For example, geese that breed in the far north migrate to the Grasslands for the winter where they use open habitats with good forage.

Waterfowl life history requirements occur as a continuum of events that overlap and are interdependent, and require diverse foods and cover (Fredrickson and Reid 1988b). A typical dabbling duck, faces five major energetic events during the annual cycle (Fig. 16) including reproduction, 2 molts, and 2 migratory periods. To successfully complete each of these events there are specific behavioral, physiological, habitat, and/or nutritional needs that must be met (Fig. 17). For example, the dietary needs for molt and migration are quite different (Fredrickson and Reid 1988b). Because feathers are high in protein, replacement requires large amounts of protein. In contrast, migration is an energetically expensive event that requires large lipid accumulation.

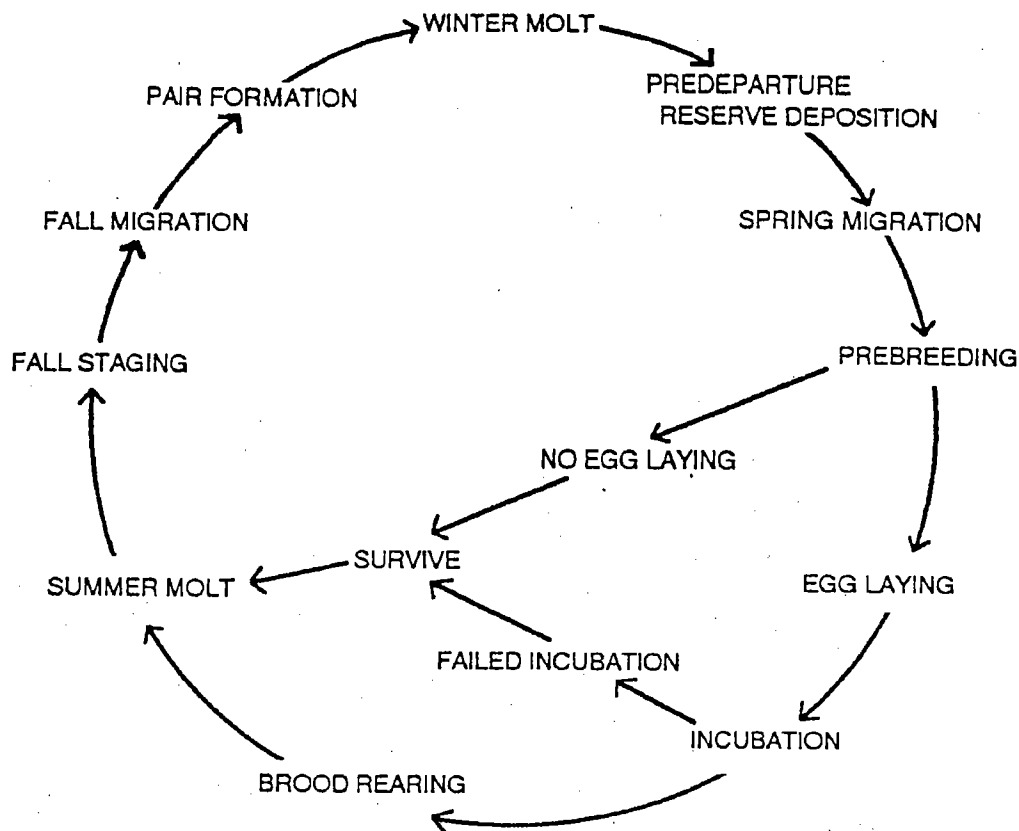


Fig. 17. The continuous sequence of events in the life cycle of a typical female dabbling or diving duck.

Thus, the foods necessary to complete both events tend to be somewhat different. A complicating factor in this scenario is that molt and migration may overlap (Alisauskas and Ankney 1992). Thus, food and other components (e.g., habitat structure) necessary for both events must be available concurrently.

Each waterfowl species that uses Grassland habitats has a somewhat different life history strategy (Fig. 18). These strategies range from arctic nesting geese that acquire necessary reserves on migrating and wintering habitats to the ruddy duck which primarily acquires necessary reserves on the breeding grounds (Owen and Reinecke 1979, Alisauskas and Ankney 1994). The locations where arctic nesting geese acquire the different components for breeding varies by species and population (Krapu and Reinecke 1992), but habitats outside the breeding area are important. Environmental conditions in different seasons and on widely separated habitats may have an impor-

tant influence on the success of sequential activities in the annual cycle of waterfowl.

Mallard strategies differ from strategies of arctic-nesting geese. Most of the lipid reserves

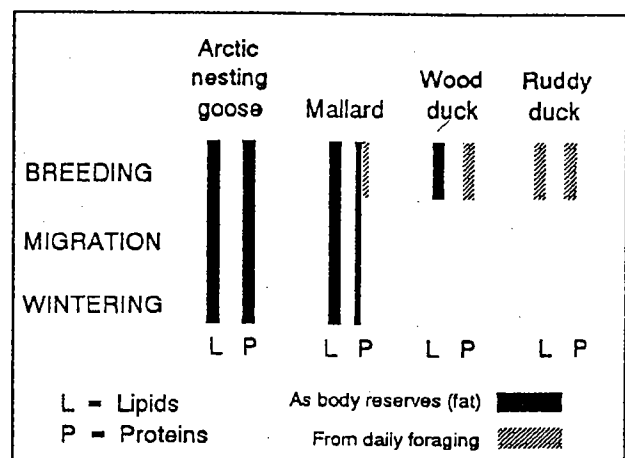


Fig. 18. Life history strategies of selected waterfowl showing when lipids and proteins are acquired from Grassland habitats.

and as much as half of the protein required for reproduction in mallards are transported to the breeding ground as body reserves (Krapu and Reinecke 1992). Wood ducks (*Aix sponsa*) and ruddy ducks (*Oxyura jamaicensis*) differ from mallards and geese because they acquire lipid and protein for reproduction primarily from breeding habitats. However, wood ducks acquire lipids prior to laying but rely on daily foraging for acquisition of all protein requirements (Drobney 1980).

Understanding these different strategies and the timing of these needs is important because land-use activities that compromise the size and quality of habitats can differentially effect the reproductive success of individual species (Raveling and Heitmeyer 1989, Nudds 1992).

Northern pintails are one of the most abundant species using Grassland habitats. Pintails either use the Grasslands as a southern terminous or continue into Mexico for winter. During their stay in the Grasslands, more than one event may occur concurrently (Fig. 19). Pintails as well as other dabbling and diving ducks have constantly changing nutritional requirements depending

upon the stage in the annual cycle (Table 15, Connelly and Chesemore 1980, Miller 1987, Krapu and Reinecke 1992, Alisauskas and Ankney 1992, Fredrickson and Heitmeyer 1991). These diverse and constantly changing nutritional requirements must be met by exploiting diverse wetland habitats where the mix of plant and animal foods are readily available.

In the Grasslands, meeting this challenge requires attention to size and distribution of wetland habitats. Because no single wetland can provide all the energetic and environmental requirements for a single species during the annual cycle nor can a single wetland type provide requirements for a group of species, each acre of habitat in this disrupted landscape is important. These interrelationships among habitats to provide critical resources emphasize the importance of all habitats in western Merced County that surround the Grassland Water District. Wetland habitats are critical, but agricultural lands such as pastures and cereal grain fields are important in California because they add open space and foods required to successfully complete the annual cycle successfully.

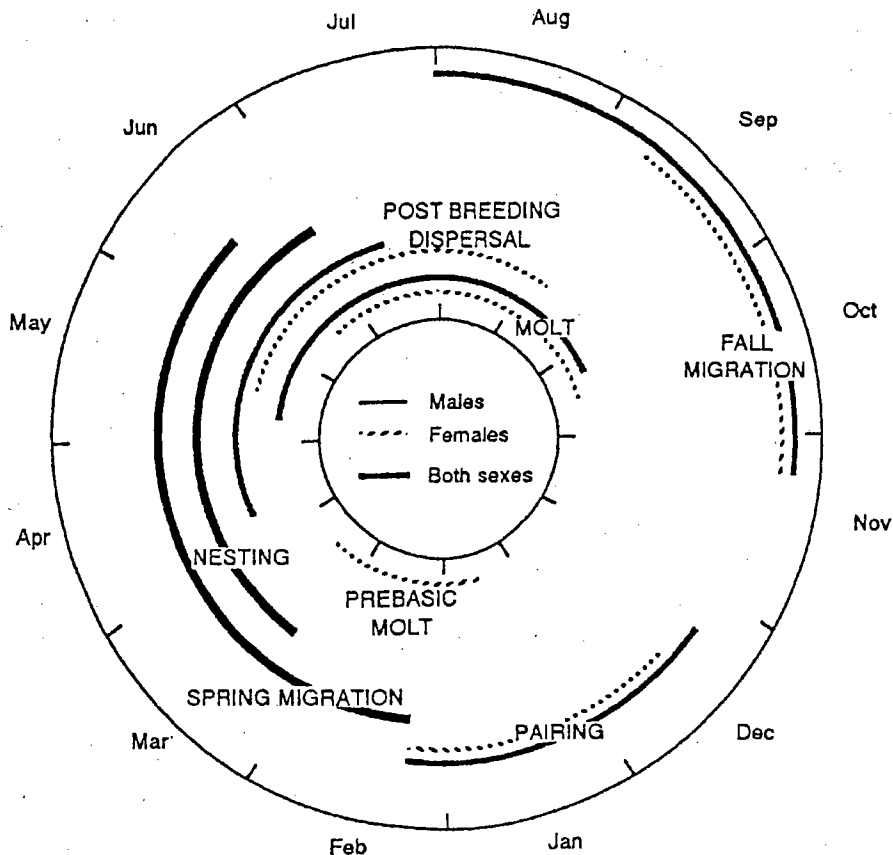


Fig. 19. Annual cycle of the northern pintail.

Table 15. General changes in nutritional requirements during the annual cycle of waterfowl.

Life stage	General needs	Specific needs		
		Geese/Swans	Dabbling ducks	Diving ducks
Premigration	High Energy	Plants-browse Aquatic tubers	Plants-seeds	Plants-Aquatic tubers Macroinvertebrates
Spring Migration	High Energy	Plants-browse Aquatic tubers	Plants-seeds	Plants-Aquatic tubers Macroinvertebrates
Prebreeding	High Protein	Plants-browse Aquatic tubers	Macroinvertebrates	Macroinvertebrates
Egg Laying	High Protein	Plants-browse Aquatic tubers	Macroinvertebrates	Macroinvertebrates
Brood rearing Early	High Protein	Plants-Browse Aquatic tubers	Macroinvertebrates	Macroinvertebrates
Brood rearing Late	High Energy	Plants-Browse Aquatic tubers	Plants-seeds	Plants-Aquatic tubers
Summer molt	High Protein	Plants-browse Aquatic tubers	Macroinvertebrates	Macroinvertebrates
Fall staging migration	High Energy	Plants-Browse Aquatic tubers	Plants-seeds	Plants-Aquatic tubers Macroinvertebrates
Pairing	High Energy	Plants-browse Aquatic tubers	Plants-seeds	Plants-Aquatic tubers Macroinvertebrates
Winter molt	High Protein	N/A	Macroinvertebrates	Macroinvertebrates

